ACTIVATING PATIENTS IN HEALTHCARE BUILDINGS: LESSONS LEARNED FROM THE URBAN SCALE

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Abstract

Objective – In this paper we aim to learn from research on an urban scale how the built environment can impact on people's physical activity and sedentary behaviour in order to translate this to designing healthcare buildings.

Background – Research shows that physical inactivity (i.e., lack of physical activity or movement) and sedentary behaviour (i.e., sitting or lying behaviour excluding sleeping) are modifiable risk factors in the rising level of chronic diseases like obesity, cardiovascular diseases, type 2 diabetes, and some types of cancer. The design of the built environment on an urban scale, like the provision of sidewalks, parks, and community facilities, has proven to be of significant importance in motivating people to be physically active and reduce sedentary behaviour, and thus to hold the potential of playing a preventive role in keeping people healthy. On the scale of buildings, the relation between the design and physical activity and/or sedentary behaviour is under-researched. Especially in healthcare buildings, patients are often confined to their bed or room, with little support nor motivation to increase their activity level.

Research question – The research questions addressed are both methodological and substantive. We investigate (1) how studies on an urban scale combine qualitative experience-oriented research techniques and quantitative tracking techniques, and what potential the adopted approaches hold for researching the built environment's impact on physical activity and sedentary behaviour on a building scale; and (2) which spaces/spatial characteristics motivate people to be physically active and reduce sedentary behaviour.

Methods – We conducted a scoping review based on journal articles combining a systematised initial search strategy with two more open selection criteria: (1) applying a combination of methods and/or (2) explicitly mentioning spatial characteristics. Grey literature was not included.

Results – By analysing articles about the built environment's impact on physical activity and/or sedentary behaviour on an urban scale, we gained insight into the methodological perspective, keeping an eye on the tools and methods used, and the substantive – spatial – perspective, listing spatial characteristics put forward as relevant to participants' physical activity and/or sedentary behaviour. This combination provides us with a broad view on population, approaches, outcomes, and constraints of research at the hinge of (urban) built environment and physical activity and/or sedentary behaviour.

Conclusion – Studying the impact of urban built environment on physical activity and/or sedentary behaviour allows to learn important lessons to further develop research about the impact of healthcare environments on patients' physical activity and/or sedentary behaviour.

Background

Physical inactivity (i.e., lack of physical activity or movement) and sedentary behaviour (i.e., sitting or lying behaviour excluding sleeping) are modifiable risk factors in the rising level of chronic diseases like obesity, cardiovascular diseases, type 2 diabetes, and some types of cancer [11]. While physical inactivity and high levels of sedentary behaviour are major challenges in society at large, they are particularly problematic in healthcare settings. Healthcare organisations face the challenge of avoiding physical decline amongst patients, especially older ones [7, 40]. When focussing on treating acute illness, staff is not always allowed to spend time with patients walking or performing other forms of exercise. Yet, keeping patients, with diverse physical and cognitive capacities, active – from early mobilisation after severe surgery [36], even in the intensive care unit [39], to long-term rehabilitation [38] – has proven to be crucial in preventing physical decline.

In most of these studies the role of the environment on a building scale is not or only marginally addressed. Only recently, studies in a rehabilitation context focus specifically on building design in relation to physical activity and sedentary behaviour. Whereas some make a comparison between wards/centres [3, 9], others consider only one ward or facility [6, 18, 37]. Depending on the adopted methodology, the studies bring forward which spatial characteristics affect participants' physical activity and sedentary behaviour and why or collect and statistically analyse (mainly self-reported) data in order to find actual correlations between built environment characteristics and patients' behaviour.

So far no studies have been found that objectively measure physical activity, yet related literature suggests the value of expanding the current methods in this direction [38]. The characteristics that are brought to the fore are mostly related to what happens inside the building, physically or socially, like the presence of obstacles in the corridor or lack of social support. When spatial organisation is addressed, the negative impact of single rooms on patients' isolation and sedentary behaviour is mentioned [3]. Healthcare facilities do not seem to be studied in their entirety as a combination of spaces with different functions, either united in one building or scattered across a campus. Connections between healthcare facilities and their larger surroundings are not addressed.

In the context of wayfinding, hospitals can be viewed as small cities, accommodating all activities of community life: sleeping, dining, business, commerce, education, maintenance, industrial processes, warehousing, and health care [2]. Therefore, urban planning and design principles should also be relevant and applicable to their design. Following the same reasoning, we aim to learn from research on an urban scale how the built environment can impact on people's physical activity/sedentary behaviour, thus improving their health and well-being, in order to translate this to healthcare building design. The research questions addressed are both methodological and substantive. We investigate: (1) how studies on an urban scale combine qualitative experience-oriented research techniques with quantitative tracking techniques, and what potential the adopted approaches hold for researching the built environment's impact on physical activity/sedentary behaviour on a building scale, and (2) which spaces/spatial characteristics motivate people to be physically active and reduce sedentary behaviour.

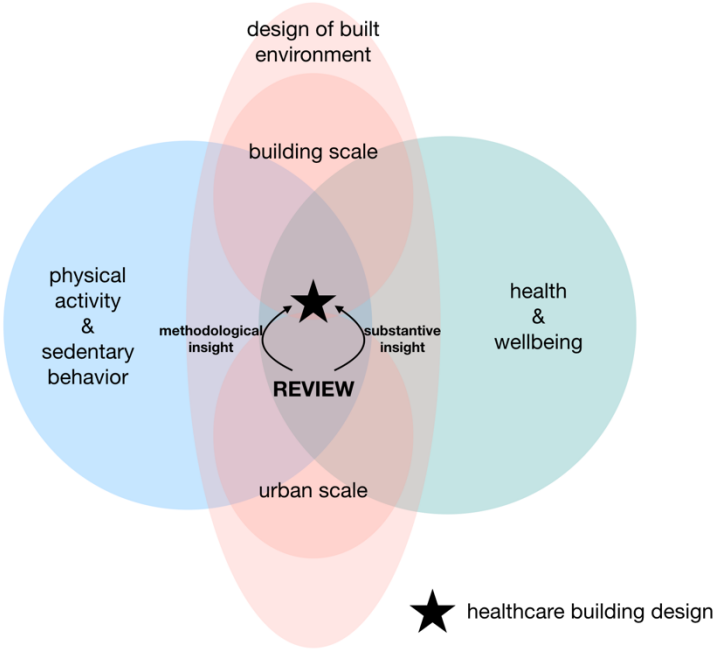

Figure 1. Research aim diagram

Review Approach

This review aims to identify relevant literature about the urban built environment's impact on people's physical activity/sedentary behaviour in order to learn from it both methodologically and substantively for future research on healthcare building design. Therefore, we conducted a scoping review, which is considered as most appropriate to identify relevant literature regardless of study design in order to gain an overview of its coverage or breadth [4]. Because of the large number of articles that seemed eligible within the review's purpose, the initial search strategy was systematised. In the final selection of the articles, however, the open lens of a scoping review was preserved.

Search Strategy

All databases available in the KU Leuven's search engine were searched: Directory of Open Access Journals; Medline (Proquest & Pubmed); OneFile (Gale); ProQuest Central; ProQuest Health & Medical Complete, ProQuest Research Library; Pubmed Central; ScienceDirect Journals (Elsevier); Scopus (Elsevier); Science Citation Index Expanded (Web of Science); and Social Sciences Citation Index (Web of Science).

In line with the review's purpose, three main groups of search terms were combined to screen titles and keywords: physical activity ("physical activity" OR "physical inactivity" OR "sedentary behaviour" OR "sedentary behavior"), urban built environment ("built environment" OR "physical environment" OR "space" OR "spatial" OR "building") and ("urban" OR "city" OR "town" OR "neighbourhood" OR "neighborhood") and design ("design" OR "planning"). Based on the envisaged application in a healthcare context we added a focus on health and well-being with according

search terms ("health" OR "wellbeing" OR "well-being" OR "well being"). We limited the search to articles from the past 5 years, written in English, which resulted in 202 articles. Grey literature was not included.

Final selection

The first author screened the 202 articles based on their titles. Titles needed to express a focus on the built environment's impact on physical activity and/or sedentary behaviour. This excluded articles where physical activity was only a means to an end in order to lose body weight, reduce stress, or increase happiness. Also excluded were articles that were purely policy-oriented or aimed to study economic outcomes. We did not exclude articles based on the study setting. This resulted in a broad interpretation of 'urban environments', from comparisons between multiple countries, to single settings like urban parks or malls.

Of the 89 selected titles, the abstracts were screened by the first author in discussion with the last author. Here the selection criteria concerned: (1) applying a combination of methods and/or (2) explicitly mentioning spatial characteristics. This resulted in 37 articles.

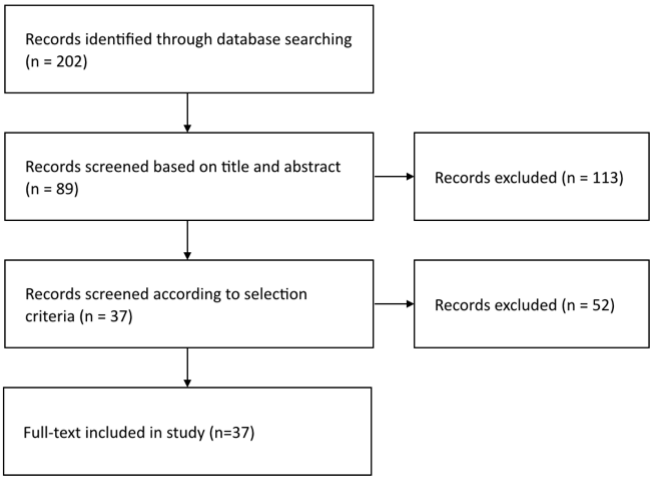

Figure 2. Study flow

Results

The 37 included articles are diverse in nature. They include quantitative [1, 8, 13–17, 20–22, 24, 27, 29, 32, 34, 42–45, 48, 49, 52], qualitative [25, 26, 31, 33], and mixed methods [30, 41, 47, 50] research reports, reviews [12, 23, 28, 35, 46, 51], a protocol [10], and an article on theoretical, methodological, and ethical questions [17]. This combination provides us with a broad view on population (children, adolescents, adults, older people with or without impairment), approaches, outcomes, and constraints of research at the hinge of (urban) built environment and physical activity/sedentary behaviour. We analysed the articles' content from a methodological perspective, considering the tools and methods used, and from a substantive – spatial – angle listing spatial characteristics put forward as relevant to participants' physical activity/sedentary behaviour.

Methodological insights

Studying the relationship between the (urban) built environment and physical activity/sedentary behaviour requires collecting data about each of them, in a way that allows making meaningful connections. The data collected about the environment concern locations and spatial characteristics. Cartographic data stored in Geographical Information Systems (GIS) [1, 10, 13–16, 21, 29, 30, 34, 41, 42, 44, 45, 49, 50], for example by an administration or as part of another research project, can be used as a basis to analyse certain features of the built environment at a certain location, e.g., the number of intersections, street lengths, or number of shops in a neighbourhood. The latter is defined according to administrative boundaries (e.g., postcodes or a perimeter around an address). Besides geographical information, insight into the built environment can be gained from questionnaires or interviews [10, 20, 22, 24–27, 31–34, 47–50]. What information will come out strongly depends on how questions are posed. Closed questions in surveys based on a pre-formulated hypothesis allow for a statistical analysis. Open-ended questions allow to discover new features at play in a particular context or to bring information to the fore about the perceived rather than measured environment. When the study focuses not on the particular context, but on the impact of predefined features, photo-elicitation – with actual [48] or manipulated [47] photos – enables participants to reflect especially on micro-characteristics of concrete built environments (e.g., presence of benches or adequate light) [47].

Given the focus on being active, studies cannot be limited to one place but require methods that allow to map where, how, and why participants move. Most of this information is closely related to the person(s) under study: apart from demographics, valuable to document are participants' personal conditions (e.g., use of assistive technology), activity (levels) and body measures (like BMI). Global Positioning Systems (GPS) are used most frequently to track where one moves at which moment [10, 13, 15, 28, 42, 43, 46, 49, 50]. Demographic data are mostly collected through survey questions. Physical activity/sedentary behaviour can be captured either through technological devices like accelerometers [8, 10, 15, 16, 28, 32–34, 42, 45], providing insight into physical activities' duration and intensity, or through less technical, more ethnographically inspired, methods that document people's routes and physical activity. These can be field observations by researchers [25], surveys [14, 16, 20, 22, 24, 26–30, 32, 41, 43, 44, 49, 52], group [10, 26] and individual [8, 10, 13, 31, 33, 34, 50] interviews, travel diaries [8, 15, 28, 49], photovoice (asking participants to document the followed routes by taking photos) [31, 34, 47, 48], or walk-along interviews [33, 50].

As to data analysis, more than half of the studies (21) conducted only a statistical analysis, seeking correlations between spatial characteristics and physical activity/sedentary behaviour [1, 8, 13–17, 20–22, 24, 27, 29, 32, 34, 42–45, 48, 49, 52]. These studies provide clear insight into which characteristics (of those advanced in the hypothesis) are relevant in relation to physical activity, sedentary behaviour, walking or cycling (in a particular context in space and time and for a specific group of participants); yet, they do not unveil why participants do what they do, or how they perceive the environment while doing so. Both regarding spatial characteristics and regarding physical activity/sedentary behaviour, a remarkable difference is found between the measured and the perceived [8, 15, 23]. Qualitative studies provide insight into why, and how (often micro-) features of the built environment play a role in physical activity [31, 33]. Matching timeframes from GPS and accelerometers can align locations with activity, but also the data retrieved through other methods could be connected. Both measured and perceived information about the built environment and about participants' physical activity can be stored in relation to geographical locations in GIS or by connecting it to locations on a map. Only one study explicitly mentioned such an approach as part of the analysis [31]. A downside of most GIS programs is that they only use 2D maps, not always doing justice to information in a 3D reality [1].

Substantive insights

The studies' outcomes addressed spatial characteristics on a macro- and micro-level. The former relates to general urban planning, the latter concerns smaller elements or interventions, more easily adapted on an ad-hoc basis. Whereas some studies make this distinction explicitly, many others mix up both.

Macro-level features, often aggregated under the umbrella term "walkability", which are frequently mentioned as relevant include density, street connectivity, mixed land-use, proximity of destinations (parks, recreational facilities, shops, restaurants, …), aesthetics (presence of nature, green or blue), and safety (from traffic and crime). In a healthcare context this could be translated to campus or building organisation with specific attention for wayfinding and positioning different functions along the way. In the quantitative studies that explicitly start from a hypothesis, these macro-level features are often the characteristics whose correlation with physical activity is to be tested [13, 14, 16, 21, 29, 32, 34, 41–45, 52]. Qualitative studies tend to focus on one characteristic or feature and dig deeper into its affordances and meanings.

Micro-level features are addressed more often, but not solely, in qualitative studies. Most frequently mentioned are benches [19, 24, 31, 33, 35, 50], availability and evenness of sidewalks [21, 26, 31, 46], clear entrance [24, 35], and light [25, 46]. Benches allow, especially older people [24, 31, 33, 50], to take a rest, but also provide a location for informal social interactions. Ottoni and colleagues [33] draw a parallel between benches, an urban feature, and porches, a building element. The availability of sidewalks is related to the macro-level feature of safety from traffic, evenness helps preventing falls and facilitates wheeled movements, important for older people and parents with children. Both issues are relevant in healthcare contexts as well. Most micro-level characteristics can rather easily be adapted at a fairly low cost [50]. Defining a hierarchy between spatial characteristics requires insight into why certain considerations are made. Van Cauwenberg and colleagues [47] illustrate this with a street where older people, unlike what was expected, seemed to dislike the presence of green. Apparently, they feared the leaves would cause slip hazard in autumn, which would limit their ability to be physically active.

Some studies' aim explicitly mentions the juxtaposition of the social and the built environment [10, 20, 24, 33, 46]. In others the social aspect is not explicated but interwoven with spatial characteristics, like exposure to the neighbourhood [16], facilitating group play and games [25], or designated social space as a destination [32, 33]. Social interactions can clearly play an important role in motivating people to be or become more physically active. Although obviously not all social relations can be brought back to spatial characteristics, the studies show that social aspects are closely related to spatial ones, either supporting or opposing them.

Discussion

This review aimed to learn from research on an urban scale how the built environment can impact on people's physical activity/sedentary behaviour in order to translate this to healthcare building design. Rather than giving a comprehensive overview of the role of the urban built environment in people's physical activity/ sedentary behaviour, the selected articles provide a broad spectrum of ideas on how this can be studied and what outcomes can be expected

in relation to the methods applied. The discussion section of many of the articles also sheds a light on strengths and weaknesses of the approaches.

Lesson 1: Develop a shared vocabulary

If the translation from one scale to another is to be successful, the phenomena studied should show sufficient similarity. Identifying search terms that allow addressing similar topics was not straightforward. In a general healthcare context articles often focus on patients' physical functioning, part of which is being physically active, next to staying in control of daily activities (taking medication, doing household chores). In high-care environments like intensive care units, "patient mobilisation" is commonly used to refer to getting people to sit up, sometimes even when still intubated, or at the most to walk along the corridor. In an urban context, "mobilisation" in relation to the built environment yielded a completely different type of studies, focussing on political movements and activism. An important distinction is made between "physical activity" and "sedentary behaviour": whereas the former refers to different activities, mainly walking and cycling, with low to vigorous intensity, the latter is used in studies about sitting versus standing or low-intensity movement. What is considered low-intensity movement in a healthcare context differs between studies (e.g. [5, 38]).

This diversity of terms and associated meanings teaches a first lesson: when physical activity, in the broad sense, is studied and reported on in relation to (healthcare) building design, it will be crucial to define a clear vocabulary that allows different parties – healthcare professionals, architects, and researchers – to talk about the same.

Lesson 2: Connect measured aspects to experienced space and time

Many of the opportunities and limitations of the applied methods we discussed are also relevant at the building scale. It is important to distinguish between what is defined as physical activity spaces in GIS, based on administrative or predefined boundaries, and what is perceived as activity space by participants [8, 14, 21, 41]. A similar concern holds for physical activity: what is measured can differ significantly from what people perceive and self-report [49]. Whereas for studies on a large scale these measures are fairly accurate, on a small scale (e.g., around the home) they risk to misjudge physical activity [34]. Using GPS to document where people actually go, and using these data as prompts for later interviews [13], can bypass the need for delineated spaces to be studied and at the same time provide insight into how these spaces and the activity that takes place therein is perceived. Indoors, however, GPS is not very accurate. Future research should therefore investigate reliable alternatives. Often qualitative studies also allow a more nuanced view on some statistically positively evaluated features, like the presence of trees (and according danger of fallen leaves) [47], or video surveillance providing a feeling of safety (or of being controlled) [35].

Combining methods can reveal different meanings attached to one feature. Mostly quantitative findings are explained by adding qualitative insights [50]. Studies combining quantitative and qualitative data collection and analysis stress how objective and subjective techniques capture different characteristics of the same environment [42, 50]. Although so far, mostly qualitative research serves the quantitative [50], their combination allows deepening insights into the mechanisms at work between urban design and physical activity/sedentary behaviour and increases the reliability of the analysis [41].

We thus learn that the applied research approach should allow to unravel people's motivation to be physically active, study how this is experienced, and at the same time make the connection with concrete locations and times in order to give meaning to measured aspects.

Lesson 3: Take into account the diversity between users

Few studies of the urban built environment's impact on physical activity/sedentary behaviour pay attention to intrinsic differences between people. Although several studies focus on older adults [10, 15, 24, 31, 33, 34, 45, 50], children and adolescents [8, 20, 46, 49], or people with an impairment [13, 45], the majority take the concept of walkability as a given. Yet, this concept is defined based on able-bodied adult persons [10]. When correlations are sought between the associated spatial characteristics and physical activity for other groups, diverse in age or ability, not surprisingly these are found only partially. Researchers focusing on children and adolescents are already aware of this flaw, resulting in the introduction of the concept "playability" [46]. Apart from bodily differences, also someone's mobility mode – walking or cycling – affects what is perceived as activity space, and which spatial characteristics play a role in this [15, 29]. For a healthcare context, these mode-specific activity spaces could point at stimulating spaces depending on the use of a bed, wheelchair, walker, crutches etc.

Studies with children [46, 49] address the influence of parents as decision makers and gatekeepers. When drawing the parallel with healthcare environments, one can easily imagine at least some patients to be dependent on others to be physically active. Considering the social, in combination with the spatial, context is essential to understand (in)dependent mobility [20].

So, a third lesson to be learned is to consider diversity within and between user groups throughout the research. Especially in a healthcare context, diversity can be found with regard to participants' bodily specificities, the mode-specific way of moving throughout the healing process, and the shared (experienced) activity between patient and caretaker.

Lesson 4: Allow a broad view on the macro- and micro level

Viewing a hospital as a small city [2] makes the scale difference between urban built environment and healthcare building negotiable. Also on a healthcare campus, spatial characteristics will need to be addressed on a macro- and micro-level. To our knowledge, so far buildings' impact on physical activity has hardly been studied on the macro-level. One spatial organizational characteristic that has been identified as (negatively) impacting on patients' physical activity is to implement only single rooms [3]. Yet, this relates solely to the initial motivation to be active and does not reveal which characteristics play a role during activity. Articles about the neighbourhood might be too different in scale, but those respectively focusing on a university campus [27] or malls [12] could provide hints about the built environment design on an intermediate level, e.g., the presence of sheltered paths [27] to facilitate moving between buildings on a campus.

As studies on built environment and physical activity in health care mostly take place within a particular ward or centre, micro-scale features come to the fore more frequently. Some characteristics mentioned in this context correspond neatly with those identified in an urban context, e.g., avoiding obstacles or providing benches. Regardless of the particular characteristics, Koppen and colleagues [23] point out the importance of understanding how a space is being read. In their research on the accessibility of recreational landscapes, they describe paths intended to be official entrance routes being read as private by potential visitors, who were then not eager to continue their journey into the landscape. Similarly, few hospital corridors are read by patients as places where they should pass frequently for their enjoyment.

The fourth lesson is threefold. Regarding the macro-level characteristics, we learn about the importance of well-thought-out (new) typologies with specific attention for spatial interventions that facilitate connections between buildings. On the micro-level, the role of specific spaces as destinations (the room, a garden, a living area or cafeteria) or connecting spaces (like corridors and atria), and how they are concatenated, comes to the fore. Additionally, attention should be paid to how both levels interrelate.

Limitations

The study shows several limitations. By conducting a scoping review with a systematized search strategy narrowed down to the last 5 years, we limited the range of the selection, possibly leaving out highly relevant literature fitting the scope but older or using a different vocabulary. We believe, however, that the resulting articles are representative for what could have been found with a more open approach. This issue was also mitigated by opting to include reviews, a protocol, and a theoretical and methodological reflection. Although including reviews opened the perspective on older literature, it also resulted in a limited overlap with two individual studies [16, 31] being part of a selected review [35]. The translation of methods and outcomes from one scale to the other could be discussed. At this point the insights gained seem at least inspiring. We will be able to assess their worth only when further, in depth exploring the impact of healthcare facilities' built environment on patients' and other users' physical activity. Finally, some of the selected articles touch upon the benefits of physical activity for (mental) wellbeing [52] and its relation with fitness levels. Both are closely related to one's health and risk of physical decline. If we aim for future healthcare buildings that play a positive, maybe even preventive role in people's health, we should not lose sight of the bigger picture.

Conclusion

Studying the impact of urban built environment on physical activity allowed learning important lessons to further develop research about healthcare environments' impact on patients' physical activity. The selected articles are diverse in nature, which allowed considering the topic from different angles and identifying (combinations of) methods and outcomes worth to be further investigated. Even though most studies used multiple data collection methods and devices, many questions about the combination remain unsolved [17]. Especially in an explorative phase, combining a quantitative and qualitative approach seems most valuable. Our review showed that when both are used, there is often little interaction between the outcomes of the quantitative and those of the qualitative part, neither during data collection, nor during analysis or when reporting. When the approaches are related to each other, it is mostly quantitative research that is enriched with qualitative information [50]. None of the studies used quantitative data as part of an overall qualitative research approach. Future research should explore how this could be realised, what this would mean methodologically, and how it would affect the outcomes.

When focussing on spatial characteristics that impact on people's physical activity, one needs to make an important distinction between the macro- and micro-level without losing sight of their mutual influence. Which category should be prioritised in design will likely depend on particular circumstances. Designing an entirely new building allows approaching the macro-level, yet in many existing buildings small adaptations of micro-level characteristics will be more feasible, not in the least because of the lower cost and shorter implementation time [50].

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References

[1] Adams, M.A. et al. 2014. International variation in neighborhood walkability, transit, and recreation environments using geographic information systems: the IPEN adult study. *International Journal of Health Geographics*. 13, 1 (2014), 43. DOI:https://doi.org/10.1186/1476-072X-13-43.

[2] Allison, D. 2007. Hospital as city. *Health Facilities Management*. 20, 6 (2007), 61–65.

[3] Anåker, A., von Koch, L., Sjöstrand, C., Bernhardt, J. and Elf, M. 2017. A comparative study of patients' activities and interactions in a stroke unit before and after reconstruction—The significance of the built environment. *PLOS ONE*. 12, 7 (Jul. 2017), e0177477. DOI:https://doi.org/10.1371/journal.pone.0177477.

[4] Arksey, H. and O'Malley, L. 2005. Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*. 8, 1 (Feb. 2005), 19–32. DOI:https://doi.org/10.1080/1364557032000119616.

[5] Åstrand, A., Saxin, C., Sjöholm, A., Skarin, M., Linden, T., Stoker, A., Roshandel, S., Dedering, Å., Halvorsen, M., Bernhardt, J. and Cumming, T. 2016. Poststroke Physical Activity Levels No Higher in Rehabilitation than in the Acute Hospital. *Journal of Stroke and Cerebrovascular Diseases*. 25, 4 (Apr. 2016), 938–945. DOI:https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.12.046.

[6] Blennerhassett, J.M., Borschmann, K.N., Lipson-Smith, R.A. and Bernhardt, J. 2018. Behavioral Mapping of Patient Activity to Explore the Built Environment During Rehabilitation. *HERD: Health Environments Research & Design Journal*. 11, 3 (Jul. 2018), 109–123. DOI:https://doi.org/10.1177/1937586718758444.

[7] Boltz, M., Resnick, B., Capezuti, E., Shuluk, J. and Secic, M. 2012. Functional Decline in Hospitalized Older Adults: Can Nursing Make a Difference? *Geriatric Nursing*. 33, 4 (Jul. 2012), 272–279. DOI:https://doi.org/10.1016/j.gerinurse.2012.01.008.

[8] Colabianchi, N., Coulton, C.J., Hibbert, J.D., McClure, S.M., Ievers-Landis, C.E. and Davis, E.M. 2014. Adolescent self-defined neighborhoods and activity spaces: Spatial overlap and relations to physical activity and obesity. *Health & Place*. 27, (May 2014), 22–29. DOI:https://doi.org/10.1016/j.healthplace.2014.01.004.

[9] Colley, J., Zeeman, H. and Kendall, E. 2018. "Everything Happens in the Hallways": Exploring User Activity in the Corridors at Two Rehabilitation Units. *HERD: Health Environments Research & Design Journal*. 11, 2 (Apr. 2018), 163–176. DOI:https://doi.org/10.1177/1937586717733149.

[10] Ellis, G., Hunter, R.F., Hino, A.A.F., Cleland, C.L., Ferguson, S., Murtagh, B., Anez, C.R.R., Melo, S., Tully, M., Kee, F., Sengupta, U. and Reis, R. 2018. Study protocol: healthy urban living and ageing in place (HULAP): an international, mixed methods study examining the associations between physical activity, built and social environments for older adults the UK and Brazil. *BMC Public Health*. 18, 1 (Dec. 2018). DOI:https://doi.org/10.1186/s12889-018-6018-0.

[11] Eyre, H. 2004. Preventing Cancer, Cardiovascular Disease, and Diabetes: A Common Agenda for the American Cancer Society, the American Diabetes Association, and the American Heart Association. *Circulation*. 109, 25 (Jun. 2004), 3244–3255. DOI:https://doi.org/10.1161/01.CIR.0000133321.00456.00.

[12] Farren, L., Belza, B., Allen, P., Brolliar, S., Brown, D.R., Cormier, M.L., Janicek, S., Jones, D.L., King, D.K., Marquez, D.X. and Rosenberg, D.E. 2015. Mall Walking Program Environments, Features, and Participants: A Scoping Review. *Preventing Chronic Disease*. 12, (Aug. 2015). DOI:https://doi.org/10.5888/pcd12.150027.

[13] Gell, N.M., Rosenberg, D.E., Carlson, J., Kerr, J. and Belza, B. 2015. Built environment attributes related to GPS measured active trips in mid-life and older adults with mobility disabilities. *Disability and Health Journal*. 8, 2 (Apr. 2015), 290–295. DOI:https://doi.org/10.1016/j.dhjo.2014.12.002.

[14] Gunn, L.D., Mavoa, S., Boulangé, C., Hooper, P., Kavanagh, A. and Giles-Corti, B. 2017. Designing healthy communities: creating evidence on metrics for built environment features associated with walkable neighbourhood activity centres. *International Journal of Behavioral Nutrition and Physical Activity*. 14, 1 (Dec. 2017). DOI:https://doi.org/10.1186/s12966-017-0621-9.

[15] Hirsch, J.A., Winters, M., Ashe, M.C., Clarke, P.J. and McKay, H.A. 2016. Destinations That Older Adults Experience Within Their GPS Activity Spaces: Relation to Objectively Measured Physical Activity. *Environment and Behavior*. 48, 1 (Jan. 2016), 55–77. DOI:https://doi.org/10.1177/0013916515607312.

[16] Ivory, V.C., Blakely, T., Pearce, J., Witten, K., Bagheri, N., Badland, H. and Schofield, G. 2015. Could strength of exposure to the residential neighbourhood modify associations between walkability and physical activity? *Social Science & Medicine*. 147, (Dec. 2015), 232–241. DOI:https://doi.org/10.1016/j.socscimed.2015.10.053.

[17] James, P., Jankowska, M., Marx, C., Hart, J.E., Berrigan, D., Kerr, J., Hurvitz, P.M., Hipp, J.A. and Laden, F. 2016. "Spatial Energetics." *American Journal of Preventive Medicine*. 51, 5 (Nov. 2016), 792–800. DOI:https://doi.org/10.1016/j.amepre.2016.06.006.

[18] Janssen, H., Ada, L., Bernhardt, J., McElduff, P., Pollack, M., Nilsson, M. and Spratt, N.J. 2014. An enriched environment increases activity in stroke patients undergoing rehabilitation in a mixed rehabilitation unit: a pilot non-randomized controlled trial. *Disability and Rehabilitation*. 36, 3 (Feb. 2014), 255–262. DOI:https://doi.org/10.3109/09638288.2013.788218.

[19] Jones, P. and Evans, J. 2012. The spatial transcript: analysing mobilities through qualitative GIS: The spatial transcript. *Area*. 44, 1 (Mar. 2012), 92–99. DOI:https://doi.org/10.1111/j.1475-4762.2011.01058.x.
[20] Katapally, T. and Muhajarine, N. 2015. Capturing the Interrelationship between Objectively Measured Physical Activity and Sedentary Behaviour in Children in the Context of Diverse Environmental Exposures. *International Journal of Environmental Research and Public Health*. 12, 9 (Sep. 2015), 10995–11011. DOI:https://doi.org/10.3390/ijerph120910995.
[21] Koohsari, M., Kaczynski, A., Hanibuchi, T., Shibata, A., Ishii, K., Yasunaga, A., Nakaya, T. and Oka, K. 2018. Physical Activity Environment and Japanese Adults' Body Mass Index. *International Journal of Environmental Research and Public Health*. 15, 4 (Mar. 2018), 596. DOI:https://doi.org/10.3390/ijerph15040596.
[22] Koohsari, M.J., Sugiyama, T., Mavoa, S., Villanueva, K., Badland, H., Giles-Corti, B. and Owen, N. 2016. Street network measures and adults' walking for transport: Application of space syntax. *Health & Place*. 38, (Mar. 2016), 89–95. DOI:https://doi.org/10.1016/j.healthplace.2015.12.009.
[23] Koppen, G., Tveit, M.S., Sang, Å.O. and Dramstad, W. 2014. The challenge of enhancing accessibility to recreational landscapes. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography*. 68, 3 (May 2014), 145–154. DOI:https://doi.org/10.1080/00291951.2014.904399.
[24] Lee, H.-S. 2016. Examining neighborhood influences on leisure-time walking in older Korean adults using an extended theory of planned behavior. *Landscape and Urban Planning*. 148, (Apr. 2016), 51–60. DOI:https://doi.org/10.1016/j.landurbplan.2015.12.011.
[25] Lindberg, M. and Schipperijn, J. 2015. Active use of urban park facilities – Expectations versus reality. *Urban Forestry & Urban Greening*. 14, 4 (2015), 909–918. DOI:https://doi.org/10.1016/j.ufug.2015.08.007.
[26] Lo, B., Morgan, E., Folta, S., Graham, M., Paul, L., Nelson, M., Jew, N., Moffat, L. and Seguin, R. 2017. Environmental Influences on Physical Activity among Rural Adults in Montana, United States: Views from Built Environment Audits, Resident Focus Groups, and Key Informant Interviews. *International Journal of Environmental Research and Public Health*. 14, 10 (Oct. 2017), 1173. DOI:https://doi.org/10.3390/ijerph14101173.
[27] Lu, Y., Sarkar, C., Ye, Y. and Xiao, Y. 2017. Using the Online Walking Journal to explore the relationship between campus environment and walking behaviour. *Journal of Transport & Health*. 5, (Jun. 2017), 123–132. DOI:https://doi.org/10.1016/j.jth.2016.12.006.
[28] MacMillan, F., George, E., Feng, X., Merom, D., Bennie, A., Cook, A., Sanders, T., Dwyer, G., Pang, B., Guagliano, J., Kolt, G. and Astell-Burt, T. 2018. Do Natural Experiments of Changes in Neighborhood Built Environment Impact Physical Activity and Diet? A Systematic Review. *International Journal of Environmental Research and Public Health*. 15, 2 (Jan. 2018), 217. DOI:https://doi.org/10.3390/ijerph15020217.
[29] McCormack, G.R. 2017. Neighbourhood built environment characteristics associated with different types of physical activity in Canadian adults. *Health Promotion and Chronic Disease Prevention in Canada*. 37, 6 (Jun. 2017), 175–185. DOI:https://doi.org/10.24095/hpcdp.37.6.01.
[30] Mirzaei, E., Kheyroddin, R., Behzadfar, M. and Mignot, D. 2018. Utilitarian and hedonic walking: examining the impact of the built environment on walking behavior. *European Transport Research Review*. 10, 2 (Jun. 2018). DOI:https://doi.org/10.1186/s12544-018-0292-x.
[31] Mitra, R., Siva, H. and Kehler, M. 2015. Walk-friendly suburbs for older adults? Exploring the enablers and barriers to walking in a large suburban municipality in Canada. *Journal of Aging Studies*. 35, (Dec. 2015), 10–19. DOI:https://doi.org/10.1016/j.jaging.2015.07.002.
[32] Nathan, A., Wood, L. and Giles-Corti, B. 2014. Examining correlates of self-reported and objectively measured physical activity among retirement village residents: Physical activity in retirement villages. *Australasian Journal on Ageing*. 33, 4 (Dec. 2014), 250–256. DOI:https://doi.org/10.1111/ajag.12055.
[33] Ottoni, C.A., Sims-Gould, J., Winters, M., Heijnen, M. and McKay, H.A. 2016. "Benches become like porches": Built and social environment influences on older adults' experiences of mobility and well-being. *Social Science & Medicine*. 169, (Nov. 2016), 33–41. DOI:https://doi.org/10.1016/j.socscimed.2016.08.044.
[34] Portegijs, E., Keskinen, K., Tsai, L.-T., Rantanen, T. and Rantakokko, M. 2017. Physical Limitations, Walkability, Perceived Environmental Facilitators and Physical Activity of Older Adults in Finland. *International Journal of Environmental Research and Public Health*. 14, 3 (Mar. 2017), 333. DOI:https://doi.org/10.3390/ijerph14030333.
[35] Salvo, G., Lashewicz, B., Doyle-Baker, P. and McCormack, G. 2018. Neighbourhood Built Environment Influences on Physical Activity among Adults: A Systematized Review of Qualitative Evidence. *International Journal of Environmental Research and Public Health*. 15, 5 (May 2018), 897. DOI:https://doi.org/10.3390/ijerph15050897.
[36] Santos, P.M.R., Ricci, N.A., Suster, É.A.B., Paisani, D.M. and Chiavegato, L.D. 2017. Effects of early mobilisation in patients after cardiac surgery: a systematic review. *Physiotherapy*. 103, 1 (Mar. 2017), 1–12. DOI:https://doi.org/10.1016/j.physio.2016.08.003.
[37] Scrivener, K., Pocovi, N., Jones, T., Dean, B., Gallagher, S., Henrisson, W., Thorburn, M. and Dean, C. 2019. Observations of Activity Levels in a Purpose-Built, Inpatient, Rehabilitation Facility. *HERD: Health Environments Research & Design Journal*. (Feb. 2019), 193758671882351. DOI:https://doi.org/10.1177/1937586718823519.

[38] Sjöholm, A., Skarin, M., Churilov, L., Nilsson, M., Bernhardt, J. and Lindén, T. 2014. Sedentary Behaviour and Physical Activity of People with Stroke in Rehabilitation Hospitals. *Stroke Research and Treatment*. 2014, (2014), 1–7. DOI:https://doi.org/10.1155/2014/591897.
[39] Sosnowski, K., Lin, F., Mitchell, M.L. and White, H. 2015. Early rehabilitation in the intensive care unit: An integrative literature review. *Australian Critical Care*. 28, 4 (Nov. 2015), 216–225. DOI:https://doi.org/10.1016/j.aucc.2015.05.002.
[40] Stall, N. 2012. Tackling immobility in hospitalized seniors. *Canadian Medical Association Journal*. 184, 15 (Oct. 2012), 1666–1667. DOI:https://doi.org/10.1503/cmaj.109-4281.
[41] Stefansdottir, H., Næss, P. and Ihlebæk, C.M. 2018. Built environment, non-motorized travel and overall physical activity. *Travel Behaviour and Society*. (Oct. 2018). DOI:https://doi.org/10.1016/j.tbs.2018.08.004.
[42] Stewart, O.T., Moudon, A.V., Littman, A., Seto, E. and Saelens, B.E. 2018. The association between park facilities and the occurrence of physical activity during park visits. *Journal of Leisure Research*. 49, 3–5 (Oct. 2018), 217–235. DOI:https://doi.org/10.1080/00222216.2018.1534073.
[43] Su, M., Tan, Y., Liu, Q., Ren, Y., Kawachi, I., Li, L. and Lv, J. 2014. Association between perceived urban built environment attributes and leisure-time physical activity among adults in Hangzhou, China. *Preventive Medicine*. 66, (Sep. 2014), 60–64. DOI:https://doi.org/10.1016/j.ypmed.2014.06.001.
[44] Sugiyama, T. et al. 2014. Perceived neighbourhood environmental attributes associated with adults′ recreational walking: IPEN Adult study in 12 countries. *Health & Place*. 28, (Jul. 2014), 22–30. DOI:https://doi.org/10.1016/j.healthplace.2014.03.003.
[45] Timmermans, E.J., Schaap, L.A., Visser, M., van der Ploeg, H.P., Wagtendonk, A.J., van der Pas, S. and Deeg, D.J.H. 2016. The association of the neighbourhood built environment with objectively measured physical activity in older adults with and without lower limb osteoarthritis. *BMC Public Health*. 16, 1 (Dec. 2016). DOI:https://doi.org/10.1186/s12889-016-3347-8.
[46] Timperio, A., Reid, J. and Veitch, J. 2015. Playability: Built and Social Environment Features That Promote Physical Activity Within Children. *Current Obesity Reports*. 4, 4 (Dec. 2015), 460–476. DOI:https://doi.org/10.1007/s13679-015-0178-3.
[47] Van Cauwenberg, J., Van Holle, V., De Bourdeaudhuij, I., Clarys, P., Nasar, J., Salmon, J., Goubert, L. and Deforche, B. 2014. Using Manipulated Photographs to Identify Features of Streetscapes That May Encourage Older Adults to Walk for Transport. *PLoS ONE*. 9, 11 (Nov. 2014), e112107. DOI:https://doi.org/10.1371/journal.pone.0112107.
[48] Van Holle, V., Van Cauwenberg, J., Deforche, B., Goubert, L., Maes, L., Nasar, J., Van de Weghe, N., Salmon, J. and De Bourdeaudhuij, I. 2014. Environmental invitingness for transport-related cycling in middle-aged adults: A proof of concept study using photographs. *Transportation Research Part A: Policy and Practice*. 69, (Nov. 2014), 432–446. DOI:https://doi.org/10.1016/j.tra.2014.09.009.
[49] Vanwolleghem, G., Schipperijn, J., Gheysen, F., Cardon, G., De Bourdeaudhuij, I. and Van Dyck, D. 2016. Children's GPS-determined versus self-reported transport in leisure time and associations with parental perceptions of the neighborhood environment. *International Journal of Health Geographics*. 15, 1 (Dec. 2016). DOI:https://doi.org/10.1186/s12942-016-0045-9.
[50] Zandieh, R., Martinez, J., Flacke, J., Jones, P. and van Maarseveen, M. 2016. Older Adults' Outdoor Walking: Inequalities in Neighbourhood Safety, Pedestrian Infrastructure and Aesthetics. *International Journal of Environmental Research and Public Health*. 13, 12 (Nov. 2016), 1179. DOI:https://doi.org/10.3390/ijerph13121179.
[51] Zapata-Diomedi, B. and Veerman, J.L. 2016. The association between built environment features and physical activity in the Australian context: a synthesis of the literature. *BMC Public Health*. 16, 1 (Dec. 2016). DOI:https://doi.org/10.1186/s12889-016-3154-2.
[52] Zuniga-Teran, A., Orr, B., Gimblett, R., Chalfoun, N., Guertin, D. and Marsh, S. 2017. Neighborhood Design, Physical Activity, and Wellbeing: Applying the Walkability Model. *International Journal of Environmental Research and Public Health*. 14, 1 (Jan. 2017), 76. DOI:https://doi.org/10.3390/ijerph14010076.